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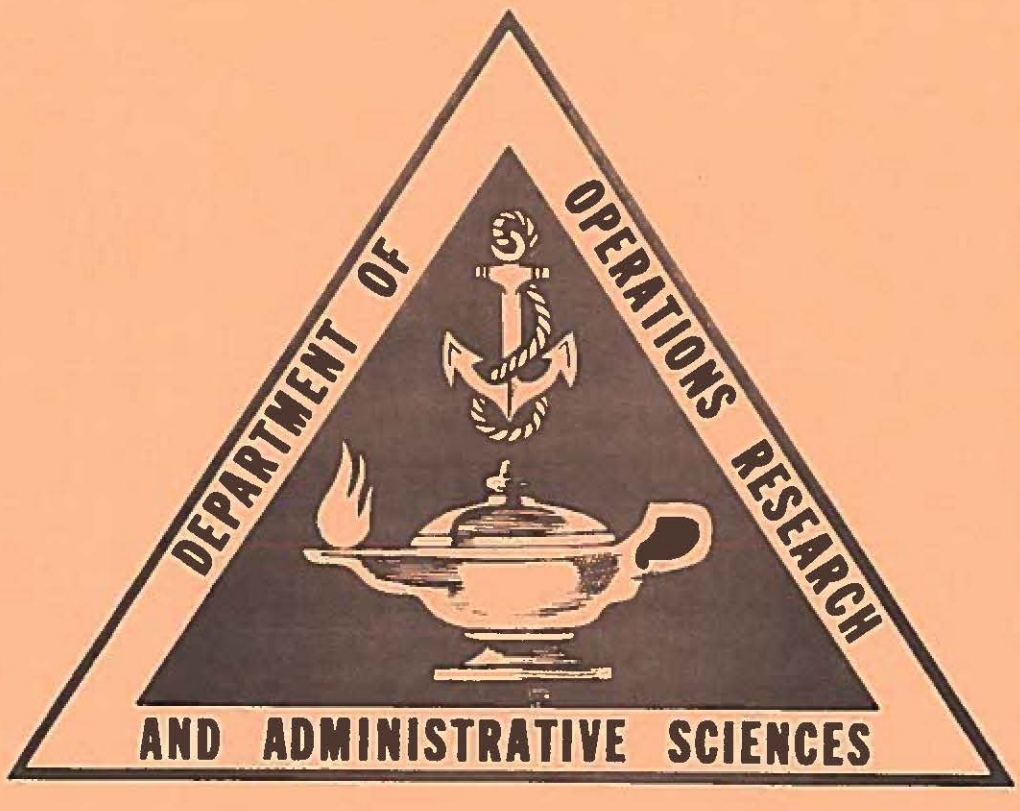

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This edition is a continuation of a student project initiated in the fourth quarter, 1968-69 academic year. Articles are selected for publication from student term papers submitted in the normal course of scholastic endeavor within courses in management offered by the Department of Operations Research and Administrative Sciences. The views expressed are those of the authors exclusively and in no way reflect the attitude or endorsement of the Defense Department, Navy Department, or the Naval Postgraduate School.

FOREWORD

AN EDITORIAL

The preceding issue of the Management Quarterly contained an article which proposed universal military training (UMT) as an alternative to the all-volunteer force ("The United States National Security Posture: A Proposal," by Frydenlund, McCarthy, Robinson and Sherman). The first three articles in this issue explore the other end of the spectrum by considering ways of utilizing our manpower force more efficiently. They advocate retaining officers for longer, more productive careers, and address some of the present obstacles facing such a plan. In its simplest terms the problem comes down to a choice between recruiting and training large numbers of personnel for brief careers (i.e., a high turnover); or reducing the turnover rate--and numbers required to be recruited and trained--by increasing the length of service from individuals. Although each article addresses a different topic, this common thread of better utilization of our manpower assets runs through all of them.

The final selection chronicles an operations research analysis of a close-to-home problem. In reviewing past Management Quarterly's we found that relatively few technical papers have been published. This is believed to be partly due to the difficulties of getting the graphs, charts, photographs, computer print-outs, etc., into print. The selection in this issue was edited by the authors to circumvent this problem for us. If you have questions concerning the paper (especially those resulting from the editing) the authors will be glad to discuss them with you and provide material which was removed prior to publication.

FACULTY OPINION

RACE RELATIONS EDUCATION and MN 3109

by Commander George L. Stansbury,
Department of Operations Research
and Administrative Sciences

In October 1972, Admiral Zumwalt sent Admiral Freeman a message asking that each Naval Postgraduate School graduate receive up to twenty hours of race relations education prior to departure for his next duty station. To accomplish this for December 1972 graduates, resources were requested from Fort Ord, and a four-hour program was designed and delivered by Army race relations facilitators.

Since that time all U.S. Navy NPS graduates have attended UPWARD seminars. UPWARD is the acronym for Understanding Personal Worth and Racial Dignity -- the Navy-wide middle-management seminar for race relations education.

The UPWARD seminar of twenty hours was put together by knowledgeable Naval officers and consultants three years ago. The seminar is conducted by majority-minority (white/non-white) teams of two facilitators who have attended Racial Awareness Facilitator Training. This training consists of four-week courses conducted at Human Resources Management Centers, located in San Diego and Newport, R.I. The objectives of the UPWARD seminar are: Personal awareness; understanding institutional racism; commitment to eliminating institutional racism in the Navy and design of a local command action program.

These objectives are approached through a variety of learning methods. Presentation is based on the philosophy that adults learn best: (1) that which they perceive to be useful to them; (2) what they personally experience; and (3) through feedback from others. The classroom is arranged with chairs placed in a circle. The facilitator functions in a role quite different from that normally associated with the "expert" teacher standing at the front of the room. The facilitator introduces the ground rules of: participation, openness and honesty, dealing in the "here and now," verbal confrontation, and speaking for yourself (owning what you say). His role is to develop a climate in which participants feel free to express themselves and learn from each other. To create this climate the facilitators divide the roles of "task/content" and "process." A good deal of time is spent on clarifying, summarizing, and insuring accurate interpersonal communications. The facilitator's role is new to most participants and is counter to the way most of us have spent our years being "taught" in school. This process has proven especially effective for learning a wide variety of topics and is being more widely used in this country each year. A variety of terms is used to describe these methods, two of which are: experiential learning methods and laboratory learning. One of the basic assumptions is that each participant comes from a unique background and set of

experiences. Thus, each participant will learn different things from each exercise while most will achieve a large part of the overall course objectives.

The MN 3109 course has been structured to achieve several objectives. The first objective is to meet the Navy's goals of at least 20 hours of race relations education for all personnel each year. To meet this goal at NPS (taking into account the length of time students are here, the resources available for conducting classes and the Navy's CNET Training Program) approximately 36 hours of the 3109 course must be spent on race relations. The remaining hours (presently 2 hours of lecture and 4 hours of lab per week) are divided about equally between alcohol/drug abuse, intercultural relations, and organization development. This breakdown closely approximates the time allocation in the Human Goals Program being developed for the operating forces.

Race Relations education can be approached on four basic levels: (1) personal prejudice and awareness, (2) minority history and culture in the U.S., (3) understanding institutional racism, and (4) critical incident handling (riots and disorders). The basic philosophy of MN 3109 is to deal with the first three levels -- e.g., creation of awareness of personal feelings and attitudes of whites and non-whites toward each other; a cultural background, which may not be generally known; and an appreciation of how our society's institutions handle racial tensions and problems in this country. These efforts are focused on the "here and now" as opposed to an examination of past incidents and situations. The education an officer receives is designed to help him be aware of the causal factors of racial tensions and give him some techniques for dealing with these causal factors.

Fundamental to all Navy race relations education is the preparation of persons in positions of leadership to be able to handle the day-to-day problems of racial differences in their units before open conflict occurs. The action programs for dealing with racial matters must be designed and implemented at the command level, and local programs must be designed to meet local needs. There is no way to design an action program for Navy-wide use which will be equally useful to an ATF in Mayport and a CVA in Subic Bay. The responsibility for effective action lies in the commitment of each command to see its own problems and deal with them. A common example is the white manager's response, "I've never seen a racial problem in the Navy." And a common non-white's answer is, "I know you have never seen the problem, but I have." Although racial problems don't exist everywhere it is apparent from recent publicity that they do exist in the Navy and that they were not recognized in time. The current race relations education efforts are designed to encourage leaders to look for, recognize and deal with racial situations in their own commands before they become a matter of publicity.

Many of the basic tenets of race relations are common to drug and alcohol abuse, intercultural relations and organization development (team building and organization renewal). MN 3109 deals in personal awareness and local action program design for these areas, too. The basic premise is that dealing with causal factors based on a personal awareness of self and an ability to recognize the local situation is more effective than trying to deal with visible results only. For a free society to exist without anarchy it must recognize and solve

persistent social problems. The goal of the Navy is to take responsibility for its internal problems and satisfy the expectations of personnel who experience these problems. In terms of "problem ownership," all of us are faced with these problems -- not just non-whites, drug users, and non-producers -- therefore, we must all, from the most senior to the newest member of each command, become genuinely committed to solving these problems which dilute our strength and ability.

Additional specific information about the Navy's program may be found in OPNAV NOTE 1500 of 11 May 1973 and OPNAVINSTs 1500.42, 5300.6 and 5350.1.

THE OTHER SIDE OF UPWARD MOBILITY

by Robert C. Nicholson

This paper challenges our present officer promotion policies as being wasteful of human resources. After discussing the problem, the author suggests some interesting alternatives.

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This paper was submitted to Professor John Senger for Group and Organizational Behavior, MN 3121.

One of the ills often alluded to in the Navy by both senior and junior officers is the existence of large numbers of passed-over officers who are no longer doing their jobs but rather seem to be waiting for retirement, secure in the knowledge that they will get their twenty years if they can just stay alive. What is wrong with our promotion system? How did these seemingly worthless officers get to positions of tenure? Or, were these officers once effective managers who have somehow lost their interest and motivation? In civilian industry, surely there are those who do not make it to the top but yet continue productive careers until retirement at age sixty-two. As pointed out by the Cordiner Commission: "Even a full military career is a relatively brief one, and service personnel, often at the height of their productivity, family obligations, and financial commitments, are forced to alter their standard of living to the reduced economic level imposed by retirement." /1 The purpose of this paper is to examine the utilization of officer manpower in the Navy to determine if the present promotion system and career patterns make optimum use of scarce manpower resources and to examine possible alternatives which might improve the system.

Loss of Motivation. The present promotion system appears in some respects to have been specifically designed to de-motivate those who were not selected for promotion. I have personally known effective lieutenant commanders who reverted to almost a vegetable status after being passed over. After fifteen years of periodic family separation and long hours of extra work--flying a night hop or preparing for an administrative inspection--they feel that their career is finished and that they might as well devote themselves to their families or spend time writing resumes in preparation for their upcoming retirement. After all, they have done their part, let some of those junior officers with a future take up the load now. Unfortunately, those passed-over lieutenant commanders, commanders and captains make up a recognizable portion of the active duty force and their lack of effectiveness wastes defense dollars that could be better spent elsewhere. Further, these officers, by virtue of their seniority, are most often in positions of authority and their lack of action and example have had a detrimental effect on Navy operations. It is often these officers whom junior officers complain about when they speak of incompetent leadership.

One cause of this loss of motivation is also apparent in civilian organizations. A satire in Life Magazine characterizes an executive whose career is studded with poor decisions but who is considered a success because he sells himself and moves steadily upward, finally becoming the Secretary of Defense./2 The article suggests that the American dream is built around moving upward in "Peter principle" fashion rather than staying in one job and becoming an expert. The executive or officer who fails to qualify for promotion is a "has been" and is expected to move aside to allow room for younger, more dynamic men behind him. Another magazine article describes a Mr. Cartwright as an outstanding personnel administrator who attempted to create a vice-presidency for himself only to have the position given to another man. His reaction was typical of many who have been passed over--even though they have attained a secure and responsible position: "But he will probably never be Vice-President. And it is from this aspect of the scenario that the average management man recoils. Cartwright would be abdicating his ambition and there is something unseemly, even unmanly in that."/3 Our culture places great emphasis on reaching the top and many organizations, including the Navy, hold out the promise of almost unlimited promotion and rapid advancement as career incentives. Unfortunately, almost all organizations are pyramids with much more room at the bottom than at the top. If an individual competes successfully he is given a carrot; e.g., a promotion to the next spot on the hierarchal ladder. If he doesn't, he is rapped with the stick of failure. Harry Levinson calls this carrot-and-stick approach asinine. In his words:

> "While the bureaucratic structure, with its heavy emphasis on internal competition for power and position, is often touted as a device for achievement, it is actually a system for defeat. Fewer people move up the pyramidal hierarchy at each step. This leaves a residual group of failures, often euphemistically called 'career people,' who thereafter are passed over for future promotions because they have not succeeded in competition for managerial positions...resentful and defeated...no longer motivated by competitive spirit...the carrot and stick are meaningless...they see little need to learn more but rather just stay until retirement."/4

The Navy promotion system formalizes this process. Of a group of 1000 ensigns, 923 will make lieutenant (junior grade), 796 will make lieutenant, 472 will make lieutenant commander, 124 will make captain and only 27 will attain flag rank./5 Those projections were made after the Korean police action, but appear to closely approximate the promotion percentages we have been experiencing since the end of hostilities in Vietnam. They show the Navy hierarchal structure to be a very steep pyramid, which in turn results in a great number of disappointed officers along the way. Additionally, the Navy considers its officers for promotion in blocks. Once passed over, it is very unlikely that an officer will be picked up in subsequent years. As an example, of 987 lieutenants selected for promotion in 1972, only fifty-five /6 had previously been passed over and of 267 lieutenant commanders selected for promotion to commander, only twenty-seven had been previously considered./7 In each case the percentage is ten percent or less, which, in the case of lieutenant commanders, is spread out to cover the three to five year period between their first pass over and retirement. Further, an analysis of selection lists indicates that only those officers who are working for admirals or who are in extremely visible jobs are likely to be picked for promotion after once being passed over. This system adds to the trauma of failing to be promoted by making it very obvious that there is little chance of being promoted thereafter. Also, the fact that a nonselectee's name is missing from a one-shot list published by naval message also makes the failure very obvious to his peers, wife, children and to any future employer. Add to this the fact that this officer will soon be retired at half pay--when his family obligations are probably at their highest and his civilian contemporary is experiencing his greatest earning power--and it can be understood why such officers almost always lose the greater part of their career motivation.

In addition to the obvious factors that may affect an officer's performance after he has been passed over, there appears to be psychological evidence that there are underlying causes associated with "status congruency--the degree to which an individual's job advancements (pay grade) are commensurate with the number of years he has worked, his age and his personal responsibilities and commitments." In a study conducted at the Navy Medical Neuropsychiatric Research Unit, San Diego, on enlisted men from three cruisers, a definite correlation between the aforementioned "status congruency" and perceived job satisfaction and life stress was established./8 Although the study was conducted utilizing enlisted men as subjects, it would appear to be equally applicable to officers, particularly when it is considered that the latter group normally advances as a block from the time of original commissioning and any deviation would be extremely obvious. Further, it was found in another study that subjects with greater education experienced greater alienation when a lack of opportunity existed./9 Each of these factors point to a fact that many of us have already observed, the passed-over naval officer is a very dissatisfied individual whose job effectiveness is greatly diminished from what it was before he was passed over.

Retirement. There are those who would say, "retirement is not such a bad deal--you can take your half pay and go get any job and make more than you did in the Navy." However, the Gates Commission Report, which studied

factors affecting the attainment of an all-volunteer force, indicates that retirees do rather poorly, job-wise, after they leave the service./10 Civilian employers do not appear to believe that an unsuccessful military career is a selling point for a middle-aged manager trying to break into industry. Besides, industry already has its eunuchs, why should they hire more? So the early military retiree can often look forward to a job selling insurance or real estate or some other equally unrewarding second career. Also, a study for the Air Force indicates that while junior officers rate highly having an opportunity for advancement, they rate a chance for early retirement as least important./11 In detachment interviews junior officers often cite, as their reason for leaving the service, the fact that even if moderately successful (i.e., promoted through commander), they will be forced out of their careers at a time when security is most important to them. At the twenty-six year point, their children will be in college and their family expenses will be at a maximum. However, the greatest loss may be to the Navy, for at the time of their retirement, these officers have attained tremendous expertise and in these times when officer manpower is becoming increasingly hard to recruit, it would appear that the Navy is discarding a valuable human resource. Also, as previously mentioned, these men often spend the last couple of years planning for their next career rather than doing a job for the Navy.

High Velocity Career. An often-cited rationale for the short time frame of a naval career and the attendant high attrition rates is the need for a youthful, virile and dynamic force./12 It is argued that younger men are needed to face the pressures of the cold war and to fight the battles if open conflict should occur. However, Vice Admiral A.E. Jarell, USN (ret.) points out that Nimitz, Halsey, Spruance, Kinkaid, Mitschner and McCain were not young men but stood up well to the extreme pressures of World War II. Also, he points out that the only officers under his command who made really poor decisions at Okinawa, where the going was really tough, were the young inexperienced commanding officers. Further, the only officer under his command who was unable to withstand the pressure to the point that he had to be hospitalized was a young lieutenant. His belief is that a military officer need not be a genius, but rather must be a "jack of all trades, must never have a one-track mind and must enjoy working with people."/13 Admiral Jarrell points to his commanding officer on a destroyer; a lieutenant commander, who finally got promoted to commander in his twentieth year and then went on to become CNO. His thesis is that experience and maturity are more important than youth and vitality; and suggests that had it not been for the respected leadership of men like Nimitz and Halsey the war might not have turned out so well. The Gates Commission also points out that as technology increases, fewer officers will actually be in the field, where youth is a requirement, but rather in technical billets where experience is paramount.

On the other hand, many people now believe that in these times of rapidly changing technology and social thought we constantly need new blood to insure that we are able to adapt to the times. They assert that older officers are set in their cognitive worlds and are unable to accept new ideas and needed change. This attitude was expressed by Lieutenant Junior Grade Jonathan T. Howe in an article he wrote for the Naval Institute Proceedings in which he attacked

the traditional way of doing things. He feels that any future war will last only a very short time and therefore sees cold bridge watches and other adversities as holdovers from the past that serve only to drive young "intelligent" officers from the service. He suggests that the Navy should emphasize the intellectual and technical aspects of a career rather than some of the unpleasant facets which are now prevalent./14 He was answered in a later issue by two "older" officers who asserted that time had proven that those who can stand up to adversity are the best leaders./15 One of these writers suggested that possibly the Navy was not Lieutenant Junior Grade Howe's cup of tea and that maybe he had better get out. Probably the answer lies somewhere between the two extremes. Certainly we need the experience--and I think we lose a lot of it through early retirements and loss of motivation by our older officers--but it is also vital that we have new blood with fresh ideas and new ways of doing things.

Another reason often given by proponents for a more youthful force is that our older leaders tend to be more authoritarian than our younger ones. They point out that while authoritarian leadership may have worked in the past, it is no longer effective because our enlisted men are now much better educated and are likely to demand that decisions be more reasonable from their point of view. It is suggested that participative leadership and leadership by objectives is more appropriate, and that the older, more authoritarian officers are unable to adapt to these styles. I have personally seen senior officers of both kinds. Certainly some of the most "people-oriented" leaders I have seen were Commanding Officers of aircraft carriers I have served on. I am of the opinion that most of these "people-type" leaders I have known have been on the way up, while most of the authoritarians have been in stagnant or pre-retirement jobs. This feeling may have been supported by a study conducted at the United States International University on manager's supervisory styles./16 This study evaluated the intrinsic and extrinsic needs of managers. It was found that the less satisfied managers were more authoritarian and that managers more often cite intrinsic or ego needs as the root of their dissatisfactions. It is possible then that our more authoritarian leadership styles are the result of what we do to our passed-over officers rather than a result of chronological age. Admiral Jarrell points out that he has known officers of sixty that were more physically fit and capable than others at age forty./17 Certainly it is known that some children mature faster than others and likewise some naval officers may develop their career potential later than others. Therefore, it seems unreasonable to tie careers to specific age or length-of-service criteria as we now do.

Deep Selection. One method of giving outstanding officers a better chance to get ahead is a deep selection process whereby an officer is selected for the next higher rank before his year group is in the promotion zone. The present percentage maximum is fifteen; however most selection boards limit deep selections to about ten percent. The deep selection concept was first "forced" on the Navy in 1959 by the Secretary of the Navy, Mr. Charles Thomas. In a letter to the rear admiral selection board Secretary Thomas directed that five percent of the selectees be picked ahead of schedule. Such officers were to be head and shoulders above their contemporaries.

Most of the Navy's admirals objected to the new proceedure, saying you can give them the stars, but not the experience. After his retirement as CNO, Admiral Robert B. Carney, USN (ret.) espoused the traditional view in an article he wrote for the Proceedings./18 He stated that outstanding officers who are flag material should be identified as potential--vice definite. Instead of early promotions, these officers should be given particularly demanding jobs to "allow them the chance to stub their toes" and to groom them for flag rank. He further asserted that "head and shoulders" officers don't come in five percent groups of every graduating class (Naval Academy); therefore, the five percent criteria would cause an artificial category to be established. He said his experience on selection boards had taught him that in each group there is a small percentage of officers who are unquestionably superior, a small percent who are not promotable and a large body who could do the job if vacancies existed; but that it is unusual to find a superstar. He believed that deep selection was desirable for that individual but that a faulty deep selection is particularly bad for group morale. Admiral Carney was commenting on an article on the same subject by Vice Admiral L. S. Sabin, USN, who was echoing the concerns of many of the senior officers then on active duty./19. Admiral Sabin was concerned that deep selectees have never really competed with those who they have jumped over. He points out that those officers' fitness reports cannot have reflected their performance if the responsibility had never been given to them. He agrees that the "head and shoulders" types must be given a chance to stub their toes. Admiral Sabin also points out that some early selectees will spend more than twenty-five percent of their careers in flag rank.

The latter concern suggests that officers can stagnate at any rank, not just lieutenant commander or commander. In a previously cited article, Admiral Jarrell pointed out that as a result of the World War I hump he was in his twenty-ninth year when he was promoted to flag rank. A good friend of his who was a general in the Airforce was ten years senior to him even though Admiral Jarrell had graduated from college four years earlier than the General. The General complained of stagnation and that he intended to get out when his thirty years were up because of the lack of career opportunity. This was hard for Admiral Jarrell to understand since the world looked good to him and he was quite enthusiastic about his own job.

It appears that one problem with accelerated promotion schemes is that they leave the officer no place to go once he reaches relatively high rank. An article in Fortune entitled "The Accelerated Generation Moves Into Management" makes the same assertions for the civilian sector./20 The author points out that the rapid promotions required to recruit and retain young executives tend to irritate older employees, cause salary compression, and most importantly, result in a marked slowdown when the executive reaches the point where higher positions are limited. If he reaches this point at an early age he can become very dissatisfied because he perceives that he is losing momentum. In other words, how do you follow the act of rapid promotions once the executive reaches the top? In an effort to accelerate outstanding line officers the Navy recently instituted a new program called "bobbysoxers." Select officers were given commands as lieutenant commanders rather than as commanders. All this plan has accomplished, in the case of aviators, has been to cut off several

years of operational flying. These officers presently have no place to go since they are too junior for the next upward assignment. A chance for promotion throughout a career may prove to be a more important incentive than rapid promotion early in a career.

The Hump. The worst periods of rank stagnation occur after each war or conflict. In order to fill the requirements for combat, many additional officers are brought into the Navy. As a result, promotions are faster and pass overs are held to a minimum. After the conflict, when forces are cut back, the higher percentage of officers remain in the upper ranks and promotions are reduced to a minimum. Presently, promotions to lieutenant commander are being held to about seventy percent as compared to almost ninety-five percent during the height of the Vietnam conflict. Additionally, promotions to the ranks of lieutenant commander, commander, and captain are being delayed as much as two years following selection. The Navy is also asking for additional legislation to force early retirement for commanders and captains in order to increase promotion opportunity for younger officers. Perhaps the worst hump occurred after the Korean conflict. Much of that hump was caused by poor planning, but as then-Commander Zumwalt pointed out, the only way we could have avoided the hump would have been to keep the Navy too small to properly fulfill its mission./21 At that time (1959) over fifty percent of the captains on the active duty list had been passed over and there were 8000 lieutenant commanders and commanders to be fitted into 2000 available captain slots during the next few years. Commander Zumwalt implied that there was no solution to the problem except to retire many of the passed-over commanders and captains early, some of whom seem to have been promoted out of a job. He concluded his article with the following consolatory remarks: "Those of us who must retire as a result of this action should be thankful for the part we have been able to play to date in the manning of our Navy and should strive to see this final sacrifice in the light of the over-all good it will do the service."/22 These words, needless to say, didn't placate many of those who were leaving and the Proceedings was deluged with comments for months to come. One captain who had been passed over for admiral was particularly bitter when he wrote to Admiral Jarrell./23 He pointed out that an officer whom he had reported on had been picked up for admiral over him. This officer had not even had a major command whereas the writer had served under several admirals and had been recommended for flag rank by five of them. He further pointed out that all of his fitness reports except one, right after he had been selected for captain, were 4.0. He said he couldn't help but feel that the other officer was selected simply because he was younger.

In another article Lieutenant Commander John A. Chastain, USN, blamed the hump problem on poor fitness reporting./24 He pointed out that during the Korean conflict, almost all combat officers were marked "outstanding." He asserted that an officer's promotion depended more on what duty he was lucky enough to get rather than on his performance and that due to the "up or out" policy, many officers were being retired without having been given a fair opportunity to make their mark. Both he and Admiral Jarrell pointed out that much of the problem could have been avoided if reporting seniors had reported objectively so that controlled attrition could have been accomplished.

Effect on Junior Officers. The primary reason for accelerated promotion programs is to attract and retain junior officers; yet more and more of them are leaving the service. Admiral Jarrell said, concerning hump legislation, that "the most disturbing comments that I have heard come from very young officers, not from those older officers who must precipitately leave the Navy. When they see that respected seniors must leave, they think about their own prospects."/25

One study suggests that organizational people, as opposed to research and development types, may be more interested in tenure than in rapid promotion./26 Whereas the research scientist is more self-actualized and looks for the job that will give him the most personal gain, the organizational type perceives that he has passed up other jobs to gain his position in the organization. Although promotion is important, he may be more interested in a secure career in which promotions are less rapid but more assured. Another study conducted at the University of Minnesota Industrial Relations Center indicates that naval officers are not necessarily a homogeneous group and may be motivated in different ways. In a sample of 271 officers, 41 percent were classified as pragmatic, whereas 47 percent were moralistic. The pragmatic group valued promotion highly while the moralistic group considered it to be a weak factor. The moralistic group had operative values of honesty, responsibility, trust, emotional stability and courage. The pragmatic groups operative values were judgment, responsibility, initiative, emotional stability, rationality, self-confidence, self-expression, foresight, resoursefulness, ambition, stamina and aggressiveness./27 It would appear from this study that a lasting career would be more important than rapid advancement for a large portion of the officers. However, a second report indicates that both groups rate job security and sea duty low while highly valuing promotion, pay, prestige and rank./28.

In an article entitled "The Credible Incentive," Captain Golden promotes the belief that "retention of officers swings on the jeweled bearings of creditability," and that throwing senior officers out on half pay while shrinking the remaining officers' incentives negates gains resulting from greater promotion opportunity./29 In one civilian company top management "hoped that 40-year-olds would respond with unbridled enthusiasm when the 50-year-olds were cleaned out." But the younger men failed to respond, because they saw that what was happening to the older men would most likely be their fate ten years hence./30

Selection Boards, Lineal Lists and Fitness Reports. Captain Worth Scauland describes the process of a selection board thusly: A board of nine officers reviews the records of 3000 officers. Selection is made by vote, and six out of nine votes are usually required for selection. Prior to the vote, each record is reviewed by a briefing officer who is a member of the board. He fills out a briefing sheet which is based primarily on fitness reports. The briefing officer reviews about 30 to 35 records an hour and assigns a grade to the officer to go along with the briefing sheet for consideration by the entire board. It is pointed out by Captain Scauland that fitness reports are extremely important in this process.

Unfortunately, fitness reporting is more of an art than a science. Some officer communities within the Navy mark most of their officers outstanding while others play it straight and try to mark more objectively. It is somewhat possible to tell the kind of marks a particular commanding officer gives by the distribution numbers along the bottom of each marking column; however, the suspicion remains that promotion depends a great deal on where the officer has been and who he has worked for, in addition to the marks received.

Officers are considered for promotion in blocks of lineal numbers. Lineal order is assigned upon original commissioning and is often based on academic performance and class standing. Because only limited numbers of officers are in the zone at any one time and since high percentages are usually selected, nonselection results in a considerable stigma on the officer concerned. In Admiral Jarrell's words: "Joe Bloke wasn't selected? He must have been in some very serious trouble."/31 Rear Admiral Duncan, who later became Chief of Naval Personnel, points out that in most professions the majority of men work effectively at a given level for years./32. He further questions the establishment of lineal numbers based on academic performance and suggests that they be revised periodically by promotion boards. Captain Needham says a promotion system should provide for: distribution of numbers of officers in each grade; a flow rate; and for attrition. He further asserts that promotion should not be a reward for long and faithful service but should rather be based upon performance./33 However, there is considerable resistance to abolishing or altering lineal lists due to a strong conviction within the Navy that an officer should not be required to work for a former classmate or contemporary. It was even suggested that officers who were deep-selected should have their lineal number readjusted to its original position once the rest of that officer's year group was promoted. Such a system where no one individual can really excel, and where there is often 95 percent selection through lieutenant commander, is discouraging to the front runners./34

Conclusions. There are good reasons why passed-over officers in the Navy lose most of their motivation. Our culture holds a strong opinion that those who fail to advance are failures. When an officer is passed over, it is painfully obvious to everyone, including his family, and he has little or no future opportunity for advancement. Only a small percentage of the officers selected in a given year are among those who have previously been passed over. Those promotions most often go to officers who have been fortunate enough to obtain "high visibility" billets. Most passed-over officers will go to very obscure, nonoperational billets, often in remote locations. Further, the passed-over officer will soon be retired, involuntarily, at the prime of his earning ability (based on civilian employment). Once retired, the passed-over officer has a high probability of getting a relatively uninteresting job on the outside, unless he has obtained a saleable skill while in the service. It is not surprising, then, that he is less than motivated for the remainder of his career. Younger officers perceive that their senior, who is often a dedicated and effective officer, has not been treated fairly, and that they are likely to receive similar treatment as their fate. Many have cited this reason for leaving the service rather than choosing the Navy as a career. The Navy is losing valuable manpower resources through inflexible career policies and action should be taken to correct them.

Recommendations. An officer should have a reasonable chance for promotion right up to the time that he is due to retire. In a previously cited article, Commander Day recommended that officers be considered for promotion throughout four years./35 He recommended that ten percent be selected the first year, twenty-five percent the second, thirty percent the third year and twenty-five on the fourth. Under the present system, a number of officers close to the cut-off point are considered. On one side of the line the officers make it and are continued on a viable career; on the other side the officers are passed over with almost no chance of being picked up. Depending on the quality of the fitness report system there is a possibility that a considerable number of the "failures" are superior to some of the selectees. If promotions are spread out, as Commander Day recommends, officers would be allowed to compete for additional years to see which officers really perform the best. The added years of consideration would give both officers additional incentive to continue their highest performance. Additionally, those officers who were selected in one of the early groups would receive feedback that their efforts were worthwhile.

Lineal numbers should at least be revised. There is no good reason why an officer's seniority should be established forever by his class standing. Actually, I would recommend that lineal numbers be abolished altogether. At the present time, unit duty assignments are most often made on the basis of who is senior rather than who is best suited for the job. If lineal numbers were abolished, the job would go to the all-round best man. Given equal ability and drive, the most experienced or most senior man would normally get the job, but it wouldn't be just because he had the lowest lineal number. Officers would immediately know that they are falling behind by the kinds of jobs they were assigned to and could adjust their actions accordingly. At any rate, nonselection would not come as such a surprise as it presently does in some cases. Doing away with lineal numbers would also solve some of the previously mentioned promotion problems. All individuals of a given rank could then be considered for promotion at the same time. Given equal performance you would again expect that the most experienced man would get selected; however, the outstanding candidate who has only held rank for a short while has an automatic chance for early selection. There would then be less stigma attached to a pass over since many officers being considered would be in the same boat. Age would not have to enter into the promotion picture unless it affected performance adversely. The officer could simply look to the next year for promotion when his added experience and continued efforts would give him a better crack at it.

Such a plan would require changes in public law to revise the criteria for early retirement. However, with the added incentive provided to work for eventual promotion,we may find that older officers are too valuable a resource to retire early at half pay.

FOOTNOTES

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/4 Harry Levinson, "Asinine Attitudes Toward Motivation--Bureaucratic Badlands," Harvard Business Review, Vol. 51, January-February, 1973, p. 70.

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/32 C. K. Duncan, Rear Admiral, USN, "U.S. Naval Seniority Practices," U.S. Naval Institute Proceedings, Vol. 87, February 1961, p. 104.

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OUR LINEAL SYSTEM: ASSET OR LIABILITY?

by William F. Horne

The author takes one of the recommendations from the preceding paper and develops it in greater detail. The benefits cited for the revised promotion system are intriguing and should be of interest to all career officers.

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This paper was submitted to CDR Benediktsson for Behavioral Science in Management, OS 3501.

The officer promotion system in the U.S. Navy is not optimal for either the Navy or the individual officer. While it appears to work in an equitable fashion for the individual by giving each a sequential opportunity for promotion, it is this very idea of sequential or lineal promotion that fails the Navy by preventing the better-performing officer from moving more quickly to the top, and depriving most individual officers of any valid feedback on their relative performance. I acknowledge the existence of those few officers singled out for deep selection as a step in the direction of matching rate of advancement to performance, but deep selection in the Navy is recognition of gross differences in performance. By denying recognition of lesser differences in performance, the opportunity to accelerate "better" officers is lost.

We have all heard the catch phrase, "Performance is the key to promotion" used to describe the present system. It is no doubt true that stellar performance is the key to deep selection, and that some minimum performance is required for selection when in the zone. The fact that officers are not considered "due" for promotion and cannot improve their position on the lineal list until their turn approaches, makes it clear that rate of advancement for the majority depends only on quotas dictated by the needs of the service, and that performance is used primarily as a tie breaker when attrition is required. This system fails to ensure that "better" officers are moved more quickly, or even steadily, toward the top. It suffers from fluctuating input levels and demands for promotion from year to year. At the point of selection for a new rank, it is a definite advantage to the prospective selectee to be in a small year-group during a force build-up compared to being in a large year-group during a cut-back.

Most career officers are never provided any reliable feedback on the evaluations of their performance, since so few are singled-out for deep selection. Not many are passed over when due for promotion until late in their careers; rather, most fall into that single nebulous category spanning the performance spectrum from, "almost fit for deep selection," to, "just barely promotable." How does an officer in this category know where he really stands? Is he almost good enough for deep selection, or barely promotable? He will never learn his relative standing unless he can obtain inside information on the proceedings of his selection board. Between selections no meaningful information is available.

If tests administered at the Naval Postgraduate School are valid, the typical naval officer rates high in need for achievement./1 Such individuals are characterized, in part, by a tendency to set difficult, but attainable, goals for themselves, and a strong desire for concrete, measurable feedback of results of their individual efforts./2 By placing all those officers who are promoted on time into a single category, an outstanding opportunity for timely, pertinent feedback is lost.

The single factor contributing most to the inadequacy of the present promotion system is the unreasoningly high regard for the lineal list of officers. Because of this regard, I claim that the promotion system depends primarily on seniority, with performance merely used as a qualifier. Most officers are promoted because their turn has arrived and they have met the minimum performance criteria (which varies with demand).

Consider the initial ordering of a group of new ensigns on the lineal list. We start with that precept of fair play, "first-come, first-served." An earlier date of commissioning rates a higher place on the list, with ties for Naval Academy graduates broken by class standing. In other cases, alphabetical rankings have been made. Admittedly, a more sophisticated system would undoubtedly require huge expenditures of time and money to produce significantly better results. Consequently, I do not strongly object to such an initial assignment of officers to the list, but wish to point out that arbitrary, even capricious methods are used.

I do object to the idea that once this arbitrary assignment is made, it becomes unlikely that an officer will ever be able to change his position relative to his peers. Assume for the moment that the only individual criteria for rate of advancement is performance, and the measure of that performance is the interpretation of officer fitness reports by promotion selection boards. If this were the case, we would expect that after a few promotions of a group of officers, the relative positions on the list would be rearranged. It would be very surprising, under such a system, to find that the relative standings of a group of commanders had not changed since they were ensigns. Such a situation would imply either: (1) the original arrangement was made with some remarkable knowledge of the future performance of the officers, or (2) performance was not the real key to rate of advancement. If we look at the real world, we see this same situation being perpetuated by the results of every selection board. If we examine an arbitrary group of officers who have never been passed over or selected early, we see that the relative positions of these officers (to others in the group) has never changed. Rare cases of disciplinary repositioning of individuals on the list are the only exceptions to this rule. Officers with the same early selection pattern and timing also maintain relative position. Since I cannot believe that original precedence arrangements of new officers are made with any divine foresight, I must conclude that performance is not the key to rate of advancement. It is easy to see why a belief develops among some officers that promotion results from getting the right boxes marked and keeping a low profile until it's your turn. Perhaps some even hold the view that deep selectees are "rate-busters."

Each selection board produces a list of selectees for promotion who fall into three categories: those not selected by earlier boards, but deemed promotable by the current board; those selected from the zone who were "due" for promotion; and those stellar performers who were good enough to be selected early (up to two years before their "turn" arrived). When promotions of the selectees commence, the sacred lineal list prevails. The officer who gets promoted first is not the best performer of the whole list--not one of the superstars whose performance has literally demanded attention and early selection--but rather, the first promotion goes to the slower developer who has been passed over by one or more previous selection boards. From a charitable point-of-view, this seems like a nice thing to do, but it is not a process which tends to accelerate movement of the best performers to the top. To be selected early, an officer has to demonstrate significantly better performance than his peers, but in recognition of this performance he ends up at the bottom of the list of new selectees. In an extreme case where the first officer below the zone is deep selected, he will be promoted near the end of the fiscal year with only a small gain in date of rank and no gain in lineal number over the next junior officer promoted "on time." Obviously there is a potential future benefit from deep selection, but it is contingent on continued stellar performance.

Strict adherence to the idea of a fixed lineal list generates the rank inversion problem that tends to deny the experience of passed-over officers to operational commands. Under the present system, a passed-over officer is, and always will be, senior to every other officer of his rank who has not been passed over. Even though they may be lacking in some areas, many could provide

valuable depth of experience in an operational environment. They are seldom so assigned because their seniority would force other more promising juniors out of important experience billets in the command.

The concept of the officer structure of the Navy as a pyramid with the attendant, "up or out," policy of promotion forces acceptance of the notion that if an officer is not fit for promotion on schedule, he will likely never be fit and therefore the best alternative is forced attrition. In studies connected with the Glacier Project, Elliot Jaques has surmised that the capacity for responsibility in individuals is characterized by various rates of development with maximum potential capacity related to age and a (correctly identified) current capacity./3 Maximum rate of growth is seen in the earlier years. Although the rate of growth drops with age, growth continues throughout the working years of all but the lowest capacity-level individuals. To force an officer up or out at some arbitrary point is to deny that individuals develop at different rates. An officer destined to rise to CNO undoubtedly shows some superiority in performance early in his career. On the other hand, why must an officer twice passed over be considered of no further value to the service? How many new officers must be recruited to replace those forcibly attrited? What assurance exists that they will be better, or even as good? What is the value of experience lost by discarding the slow developer? These questions must be weighed in the environment of rising recruiting and training costs.

What would happen in a large corporation if management personnel were grouped by the year in which employment commenced, periodically considered for promotion in those groups, and either promoted or given a "black mark", with anyone receiving two consecutive "black marks" fired without further recourse? I predict that junior managers would be discouraged from working under such a policy, particularly if no feedback were available to indicate evaluations of performance in the periods between reviews.

Can the Navy get the maximum return from its investment by demanding school-like progress from the officer corps? Its new officers come from diverse backgrounds throughout the United States, with educational levels varying from (occasionally) less than a high school diploma to multiple advanced degrees. They possess a certain minimum (as measured) intellect, with ages ranging from the early twenties to the thirties; and immeasurable differences in goals, personal maturity and attitude toward the service. They are grouped by the calendar, given training varying from a minimum of indoctrination to the acquirement of a naval specialty, and sent to serve in all the differing units of the Navy. Finally, they are rated periodically on a scale without definable (at the local level) units, and then considered "due" for promotion in groups defined by narrow time slices across the order in which they commenced their service. Performance is supposed to be the criteria for advancement, but unless an officer is a superstar, or doesn't meet the minimum requirements for promotion, he will be selected with his contemporaries and promoted in lineal order as vacancies occur.

In an atmosphere of spiraling personnel costs, reductions in force, and continuing budget cuts, the Navy must make every effort to obtain maximum

return for each dollar spent on recruiting and training. Can we afford to create dissatisfaction by stifling incentive, or perhaps forcing officers into patterns of responsibility in which they are uncomfortable? Jaques holds that dissatisfaction results from promoting either too fast or too slow./4 Since individuals with a high need for achievement characteristically set difficult but achievable goals for themselves, it follows that maximum benefit for both the Navy and the individual officer would derive from an atmosphere wherein each officer could accurately assess his own potential relative to the possible goals, and receive adequate feedback to guage his progress toward his own goal. I maintain that every ensign does not aspire to become the Chief of Naval Operations. McClelland insists that individuals high in need for achievement set realistic goals for themselves and crave concrete, measurable feedback on their performance./5 In order to provide such feedback on individual performance, the promotion system could be changed to one wherein rate of advancement actually depends on performance. There should ultimately be a system that allows as many different rates of advancement as there are evaluations of performance. Each officer should advance at a rate commensurate with his own performance and the needs of the service. Relative change could be in either a positive or negative direction to indicate the full spectrum of possible performance. A rate reflecting individual performance would remove the strong delineation that presently exists between early selectees, on-time selectees, and passed-over officers. It would remove the present minimum time restrictions and allow truly great performers to advance in record time. It would eliminate the category of passed-over officers, and, consequently, wipe out the rank inversion problem that prevents detailing these officers to operational commands.

Before I make too many great promises for a revised promotion system, I shall volunteer some ideas for changing the present system to one which I believe would provide increased benefits to both the service and the individual officer. Following my proposal, I will attempt to estimate effects on the Navy and individual officers.

The idea of a promotion system which could yield individually tailored advancement matched to performance sounds complex and idealistic, yet it could be done rather simply. Under the current selection system, promotions are made from selection lists in lineal order. Although selection board proceedings are not released, it is known from various accounts of typical board procedure that boards express varying degrees of confidence in officers selected for promotion. To be blunt, the boards do not find all those selected to be equal. It would be a simple step, but a just reward for performance, to rank and promote officers in the order of preference expressed by the board.

It would follow that selection boards express varying degrees of confidence in those officers not selected for promotion. Their relative performance could also be recognized by reordering of lineal positions without a change of grade (promotion). This would provide each officer positive feedback concerning the selection board's evaluation of his performance.

Since it is desirable to ensure rapid progress for top performers, and frequent, concrete, measurable feedback to all officers, the elimination

of promotion zones would provide a larger pool of officers of any particular rank from which to select those desired for promotion. Annual selection boards could then provide an annual feedback to every officer concerning his performance.

In sum, my proposals are:

1. Eliminate promotion zones and thus make every officer eligible for annual consideration by a selection board.

2. Promote those selected in order of preference of the selection board, and reposition those not selected on the lineal list in order of the preference of the board.

In my opinion, the benefits of such change would be numerous, and outweigh adverse effects.

First, the Navy would realize a gain because the path to the top ranks and positions of responsibility would be restricted only by the ability of the individual officer. An annual report of selection board evaluation of the relative performance of each officer would provide the concrete, measurable feedback so much sought after by individuals with a high need for achievement. Annual restructuring of the lineal list would tell each officer exactly how he rated in relation to his peers. After a few years of service, an individual could project with some confidence how high his efforts could take him in the Navy. There would be a real basis for setting personal goals. The individual officer could easily compare his annual movement toward the top of the list of officers of his grade. It would be a simple matter to see if progress was faster or slower than the norm. This is concrete, measurable feedback. For example, if in a particular year, five hundred lieutenants were promoted and one of those not promoted moved more than five hundred names closer to the top of the new lieutenant list, he would have a positive indication that he was moving up faster than the average. In similar fashion, any officer could measure his own progress. Annual incremental restructuring of the lineal list would provide an infinite number of possible advancement rates. There would be a much better chance of matching rate of advancement to the growth of capacity of each officer. Officers who would currently receive normal promotion, but display somewhat above average performance would know that they were officially above average and likely be encouraged to increase their efforts. Below average performers would also receive timely notification of the results of their efforts. An officer who could, early in his career, project that he would not rise higher than a particular rank, could have time to test the results of increased effort and then if he chose, opt to leave the Navy voluntarily at a time of his own choosing. Forced attrition could possibly become a thing of the past.

The status of "passed over" would practically cease to exist. If we assume that being passed over is a result of inadequate demonstrated performance under the current promotion system, it would follow that under the proposed system, such officers would never get near the top of the seniority list in their rank. Successful progress through any lower grades would be

slow, giving the Navy longer, more economical service in return for its investment, and also allowing more time for the individual to gain experience and knowledge and grow in capacity. When the slow individual reached the peak of his development, his performance would simply keep him from ever reaching the top of the seniority list in his then current rank, thus avoiding the problems of the "Peter Principle." Since attrition by default would disappear along with the category of passed-over officers, selection boards should continue to be charged with identification of any officers whose performance warranted being "fired" from the Navy.

While it seems that the burden of the promotion selection boards would be greatly increased, I don't feel this would be the case. The initial reviews of large numbers of new officers would be undeniably time consuming, but the cumulative effects of successive reviews would enable development of some method of characterizing individual potential. As time passed, selection boards for senior ranks might only have to confirm the standings generated by previous boards. Individual officers would benefit because overall progress would be affected less by variances in particular selection boards. Ultimately selection boards could meet and return their findings without even being provided with quotas to fill. The output of a board would be a list of all officers of a grade starting with the board's first choice for promotion ranging in order down to the last choice, plus the names of any officers to be separated. Promotion of the required number could then be made from the top of this list. In the event of a rapid increase in force size, temporary promotions could be made from the remaining list with some confidence that the next selection board would confirm most of them. Force reductions could be made by selectively cutting officers whose progress had stagnated (i.e., starting at the bottom and working upward). There would no longer be the problem of varying opportunity caused by big zone/small quota and small zone/big quota situations. Outstanding performers could gain requisite experience and move into top-level management positions in less time. Where necessary, tour lengths could be adjusted to give more or less experience as deemed necessary based on projected future potential. Longer, lower rank service from slower developers would reduce personnel costs without shattering morale. In the Navy today, there are 1,500 lieutenant commanders who have been passed over one or more times for commander. Most will never make commander. With retirement assured, nearly all will serve up to 40 per cent of a twenty-year career as passed-over lieutenant commanders. Since these officers are presumably those with lower demonstrated performance, the costs to the Navy would have been much less if they could have progressed more slowly to their ultimate rank. Few were passed over for lower grades; rather, they were in the pack, being promoted on time until they were passed over for commander. Some might have been better prepared if given more time to develop. Others might never develop sufficiently to warrant selection, but in either case it would benefit the Navy to cause them to serve a greater portion of their careers at less pay. There is a possibility that, given an early prediction of never going beyond lieutenant commander, none would remain, but I consider that unlikely. At worst, that would mean voluntary attrition of slow developers, and that's not all bad.

One of the most profound effects possible would be the complete debunking of every myth or sea story that presently exists concerning the advantages or

disadvantages of particular types or locations of duty. After a few years of operation, sufficient empirical evidence should accrue to prove or disprove such tales.

The Navy has recognized the need for feedback by requiring junior officers to view their fitness reports and be counseled on their performance. This is a commendable action but one which contains too many variables to be of maximum benefit. While a commanding officer may attempt to convey to one of his officers what his fitness report really means, it is not certain that selection boards will have the same assessment. The situation is further confused by the junior officer's own perception of the validity of his commanding officer's opinion. Annual feedback from the selection board might open the eyes of both the subject and the writer of the fitness report.

A problem linked with my proposals is that of correlating rank from one service to another with a different promotion system. It is possible that this could be worked out by annually reassigning constructive dates of rank. It is also possible that legal requirements would not allow promoting out of lineal order, or even adopting such a system on a unilateral service basis. I will close by declining to speculate on the degree of legal entanglement involved in any attempt to modify the existing system.

Editors' note:

A problem not addressed by the paper is the situation where officers of the same grade in a particular unit have their lineal positions reversed by a board. Solutions such as having a senior work for a junior by maintaining the status quo, or conversely, making the switch and forcing sudden role reversals, have some serious defects. It is a subject which warrants further consideration and would make a good topic for a paper--anyone interested?

FOOTNOTES

/1 Emmett J. Knapp and John M. Wyatt, "Aptitude, Personality Traits, and Past Academic Performance as Related to Academic Achievement in a Graduate School" (Monterey: Naval Postgraduate School, Professor John D. Senger, June 1969).

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THE AGING PILOT- ARE THERE REALLY NO OLD, BOLD PILOTS?

by Sidney E. Wheeler

Although this paper is written about Naval aviators, the concept of longer, more productive careers can be applied to the entire officer corps. As for the aviators, maybe the captains who lost their flight pay can make it back to the cockpit yet!

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"THERE IS NO SUCH THING AS AN OLD, BOLD PILOT; ONLY OLD PILOTS AND BOLD PILOTS"
-- common twentieth century aviation maxim

Introduction

The word aging, particularly as it applies to a specific task set, is an extremely relative term. An olympic swimmer is usually too old to compete effectively by the time he reaches twenty years of age. Most professional athletes are getting too old for effective participation by the time they reach their fourth decade (George Blanda excluded) and the same seems to apply to managers and executives,judging from contemporary hiring practices. Conversely, it is not at all uncommon for forty-five year old astronauts to perform the physically and mentally demanding missions into the unknowns of space, nor is it in the least uncommon for new giant passenger aircraft, with hundreds of passengers' lives in the balance, to be entrusted to airline captains in their late fifties.

Consider two widely-held opinions concerning aviation: One states that combat pilots should be of very young age, since only the younger pilots have the necessary aggressiveness to carry out combat operations. This view is manifest in the policies of the Israeli Air Force where successful combat pilots are precluded from combat missions after age 30. Another widely-held opinion, contradictory to the previous one, is that a truly proficient pilot needs very comprehensive flying experience, and thusly, he must of necessity be older.

Which of these opinions is valid--or are they both? With the wide range of aircraft types and mission profiles (and subsequently wide variety of pilot requirements and stresses) perhaps there is room for both to be true.

In considering these opinions and the effects of change with age on pilot performance in general, several questions arise, such as: What decrements in performance are attributable to physiological factors dependent on age; does learning rate affect performance; how do psychological factors and mental stress reactions vary with increasing age; how does the individual pilot's perception of the aging process affect his actual performance; and, is the term aging actually attributable to chronological time passage or is it a much more complex process involving much more than mere passage of time? In any answer to the above questions one must also ask: On what are the answers based? Have there been sufficient studies from which to draw answers? Are these studies broad enough to cover the subject and are they of sufficient length to be longitudinally significant? And, it must be asked of any study purporting to draw any conclusion about pilot reaction: Were the studies conducted in a controlled laboratory environment or were they deduced from in situ information? On this answer rests the validity of the entire study, for only then can the psychological stress of flight be incorporated with whatever other reaction, reflex, or response being tested for, whether it be mental or physical.

In discussing a similar topic, the Navy's increasing use of flight simulators vice actual flight for training purposes, a fellow Navy pilot and I recently came to the conclusion that the way to make these simulators as realistic as possible was figure out the mean time between fatalities in the particular type aircraft being simulated, and then program a hammer to swing into the pilot's face, smashing it, with the mean time between swings matching the mean time between fatalities in the actual aircraft. Only then could the element of uncertainty, with its absolute results, play a part in trainee reactions. This, of course, was said in jest, but it does very vividly point up the great fallacy in comparing laboratory tests to reactions in a live world situation. Every pilot knows that there are no deaths nor serious accidents attributable to pilot errors resulting from mishaps in flight simulators. Regardless of how intently he may try to play his part, this will not be forgotten.

Having discussed the differences between in situ and controlled laboratory studies as they relate to flying evaluation, an exploration into the aging process as it relates to the air crew will be attempted.

This exploration will take the form of analyzing the various tasks of flying, discussing some of the results of recent studies which might be applicable and making some very general observations. Hopefully these discussions

will be enlightening, but the reader must be forewarned that the conclusions of an earlier researcher are still valid: "All the psychophysiological research on aging actually does not allow any consequences to be drawn with respect to limitations of assignment or even eliminations of physically healthy pilots." /1

Pilot Functions

Before one can attempt any research into the effects of age on pilot reaction, whether approached from the physiological or psychological aspect, one must first have some idea as to what a pilot's functions are. As mentioned in the introduction these functions vary widely according to aircraft and mission type. All, to varying degrees, contain some or all of the following basic functions:

1. Attitude, altitude and directional control
2. Navigation and target identification
3. Monitoring and adjustment of aircraft systems, such as hydraulic, electrical, weapons, sensors, and conditions of auxiliary equipment such as gear, flaps, deicers, etc.
4. Inter- and intra-aircraft communication and cooperation.

These functions require vigilance, concentration, perception, differentiation, identification, processing, storage and retrieval. Frequently they require speedy decisions and equally speedy transfer of these decisions into control actions, manipulations or some other activity./2 Thus, functions required of the pilot are watch-keeping, sensory-perceptual, intellectual-motor, perceptual-motor, and information sorting and storing functions. With increased automation, watchkeeping becomes more and more important.

Aging Effects on Pilot Performance, Physical Abilities

One of the philosophies most ardently ingrained in a naval aviator is that he must keep physically fit so that he may better react to the stresses intrinsic to aviation. The logical corrolary is that as he grows older his physical fitness, and thus ability to withstand stress, decrease. Wegman and Klein's NATO study refute the basic premise in this argument--that physical fitness (as it is used by the military to mean athletic fitness) increases stress tolerances. In a controlled study pitting trained atheletes against untrained men, they tested for reaction to hypoxia, acceleration (G forces) exercises, and orthostatic stress. The tests were performed at several altitudes. They found that the differences in physical abilities decreased with increasing stress, suggesting that over-training beyond that necessary to meet requirements is not necessary. They concluded: "A better physical fitness does not imply higher tolerance to stresses other than exercise. There is no indication which supports the idea of an improvement of human tolerance to environmental extremes by physical exercise training." /3 If the basic premise is destroyed, then apparently so is the corrolary. If it is not necessary to be athletically trained to withstand stress, then decrements in athletic ability with age should present no problem.

The previously-cited authors did mention that physical exercise did increase tolerance to the stressor, exercise. What of this as one gets older? What is the physical work load of flying? Evidence from many studies measuring the energy requirements required to fly an aircraft are in existence. For example, a study conducted in World War II showed that caloric cost of flying was about 120 kcal/hr. or only about 20% to 30% above the normal seated levels. This study also found that the energy costs in all flying conditions, that is, traffic pattern, night, turbulent weather, etc., was 15% to 20% higher for novice pilots than experienced hands. A 1969 study confirmed these studies as they apply to modern aircraft./4 This caloric expenditure of about 120 calories/hr. is well within the range of a 65 year-old man in fair condition. In these generalities about condition or lack of it, it is assumed that the reader recognizes that any condition must include agility enough to get into and out of the aircraft, and dimensions trim enough to permit the subject to fit into the cockpit. Judging from these two mentioned studies, the purely physical aspect of aging should not preclude flying until a very late age (actual ailments not withstanding). Tyler's conclusions concerning age differences in special physical abilities leads to a concurring conclusion./5

There are two other physical-condition aspects that are important but which are usually left out of studies. The first is the effect of physical condition on survivability should the pilot and his machine cease to operate together for some reason. Physical agility, strength and endurance cannot be denied importance in the likelihood of survival in a crash, ditching, bailout or ejection. This introduces the second neglected factor, e.g., the mental aspects of confidence and well-being brought on by good physical condition. Past emphasis on physical condition has led the pilot to believe that he can do a better job if he is fit. Thus when fit, he feels more capable and has more confidence in his ability to survive.

The so-called "Thousand Aviator" study of the U. S. Navy, commenced in 1940, is the only timely longitudinal study of individual aviators and is now in its thirty-third year. Unfortunately, this study has been concerned almost exclusively with defining physical standards and studying heart and blood pressure relations, and does not address the quality of performance with time nor the psychological aspects of performance. Thus far, the major conclusion of the study has been that physical standards have been too stringent./6

Learning and Learned Tasks

In a previous paper on learning change with age, the conclusion was drawn that there is very little decrement in learning ability with age prior to the onset of senility or physical impairment, provided the proper motivation was present./7 Further, it was found that learned experiences of a similar nature reinforce learning of a new task. Cited also were results of studies which concluded virtually no decrements in perceptual or vigilance tasks with age (up to the same limitations previously mentioned).

A study of airline pilots transitioning to newer aircraft found that there was a greater failure rate with pilots over 40 when dealing with complex

new equipment (a negative-transfer phenomenon)./8 However, this study did not take into account previous education in the basics of the more complex equipment nor some of the motivational factors involved, and did not deal directly with learning ability. Others, such as Tyler, reach opposite conclusions. There is no conclusive answer, but it seems sound to postulate that there is not a sufficient decrement in the learning ability of an "over 40" pilot to preclude him being able to learn a new aircraft. This assumption does not presuppose or stipulate any conclusions about his ability to apply this learning in such a way as to be as effective a pilot as a younger counterpart.

Performance, Reaction Time, and Stress

If a qualitative difference in performance does take place as a pilot ages, it must produce differences in reaction time or differences in reaction while under stress--particularly psychological stress--or a combination thereof.

The study by Lukyanov and Frolous of stress and the human operator has explored the reactions to physical and emotional stress, both qualitatively and temporarily. They have reported the physiological reactions to both types of stress. Their subjects range from laboratory subjects to cosmonauts engaged in space walks. Though they made no attempts at any correlation of reaction with age, they did make a statement concerning space flight, which I think is applicable to any flight: "In actual flight, the emotional stress predominates, ... against the background of comparatively low physical effort."/9

Tyler's conclusions concerning motor abilities and performance do indicate a decrement with age, but fail to remark on the amount of decrement./10 Miles indicated a 10% decrement in this area in the 5th decade./11

As for reactions to emotional stress, they are highly individual. Lazarus, one of the foremost researchers in the area, states, "stress reaction patterns to the same stress situations vary greatly from individual to individual; patterns of reaction are undoubtedly determined by characteristics of personality, but little attention has been given to the personality, determinants of coping."/12 Due to the individuality of the nature of stress reaction, any latitudinal study of stress reaction with age would probably be meaningless except in very broad terms. There are studies of changing personalities with age, but these deal with people in what is normally "old age",in their mid sixties or older, certainly beyond the age being considered in this paper.

Psychiatric studies have shown that there are tendencies toward higher dominance, more anxiety, more intolerance and conservatism as persons age, but they report also that the deviations are certainly too great to consider the results to be predictive./13 Such studies generally were of psychiatric patients and, thus, the generalities of the statements are compounded further.

If we are to obtain any meaningful conclusions concerning psychological stress reaction variance with age, we must make longitudinal studies of pilots'

stress reactions, following a cross section of individual aviators for several years. Even periodic questionnaires concerning attitudes toward various situations would be of considerable help. No such study conducted with pilots or any similar group seems to be available at this time. Most of the opinions that exist, such as: Younger pilots are more aggressive; younger pilots are not bothered by night traps (night carrier landings) as much as older ones; the kids are the hot shots; there are no old, bold pilots, only old pilots and bold pilots; etc.; are just that--opinions. Where these opinions stemmed from is another tale altogether. There are probably some facts to back up each, but there is certainly ample counter-evidence as well. There is no evidence yet available to indicate that younger POWs in Vietnam held up any better under mental and physical stress than did the older ones. If press accounts can be believed, certainly there were few more aggressive and daring fighter pilots than Gen. Robin Olds, who was no spring chicken at the time of his exploits. The percentage of decorations for bravery awarded pilots matches their percentage age distribution for those who were allowed to fly combat missions. (These latter two examples are certainly open to counter discussion.)

The conclusion is that there are no hard facts available to make valid judgments as to age-related reaction to mental stress in well-trained aviators.

Summary

The act of piloting an aircraft involves watchkeeping, sensory-perceptual, intellectual-motor, pure motor, and reflex-motor functions. Of these only sensory functions can be shown to decrease with age in any appreciable degree.

Little evidence exists to determine what relation the interaction of physical or mental stress has on modifying pilot action in a real world environment. Few lateral studies and no longitudinal studies correlating age with reaction were discovered.

Conclusions

As with almost any proposed task in our society based on materialism, there must be some financial advantage in evidence to justify expenditure for any type of study. The sooner a gain can be realized, the more likely is the expenditure. Several of the writers on the subject of pilot functioning in relation to advancing age expressed a desire to pursue such a course and stated paucity of funds as the reason for being unable to follow through. In an increasingly economy-minded state, there is a definite need for such studies. The amount of money invested in the training of a military pilot is substantial. The tendency toward removing him from active flying in fifteen or less years of flying--usually by his fortieth birthday--is wasteful of manpower, time, and money. If it can be shown that this period can be prolonged, substantial savings could be realized.

An attempt to determine when a pilot is too old to be effective could be accomplished by a two-pronged attack. One tack must be to determine what

the real requirements for an effective pilot are for each of the facets of military aviation. This could be conducted by cross-sectioned studies; longitudinal studies would not be necessary.

The other tack would be to determine criteria for establishing a "behavior age" or "performance age" which could be determined by observations (physical and psychological) in the live environment. This behavior age would naturally vary with each individual and certainly not be based on chronology alone, as is now the practice. Lateral and longitudinal studies are called for to establish this criteria.

By establishing these two sets of criteria a more realistic approach could be made to making a rational determination of when a pilot is really "too old" to be an operational pilot.

FOOTNOTES

/1 J. Szafran, "Psychological Studies of Aging in Pilots," Aerospace Medicine, Vol. 5, 1969.

/2 H. J. Grunhofer, Col. GAF,and H. Gerbert, "Psychophysiological Processes of Aging," Agard Conference Proceedings, No. 81, 1970.*

/3 H. M. Wegmann, and K. E. Klein, "Physical Training Status in Relation to Stress Tolerances," Agard Conference Proceedings, No. 81, 1970.*

/4 D. E. Littel, "Energy Cost in Piloting Fixed Wing and Rotary Wing Aircraft," Journal of Applied Psychology, Vol. 26, 1969.

/5 Leona E. Tyler, The Psychology of Human Differences (New York: Appleton-Century-Crofts, 1965).

/6 R. E. Mitchell and others, "The Thousand Aviators--A Thirty Year Follow-Up," Agard Conference Proceedings, No. 81, 1970.*

/7 S. E. Wheeler, "Teaching an Old Dog New Tricks" (Unpublished Paper, August 1973).

/8 F. S. Preston, "Twelve-Year Study of Airline Pilots," Aerospace Medicine, Vol. 3, 1968.

/9 A. N. Lukyanov and M. V. Frolov, Signals of Human Operator State (Moscow: Navka Press, 1969, NASA translation, 1970).

/10 Tyler, loc. cit.

/11 W. R. Miles, "Psychological Aspects of Aging," Problems of Aging (Second edition; Baltimore: Williams and Wilkins, 1948).

/12 Richard S. Lazarus, and Edward M. Opton, Jr., "The Study of Psychological Stress," Anxiety and Behavior (New York: Academic Press, 1966).

/13 Tyler, loc. cit.

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*AGARD: Advisory Group for Aerospace Research and Development of the North Atlantic Treaty Organization. Conference No. 81, conducted in September 1970, was on "Physical Fitness in Flying including the Aging and Aged Aircrew."

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A STUDY OF THE UTILIZATION OF SAILBOATS

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While Messrs. Quade, Boucher, et al. ponder such weighty problems as missile force requirements, etc., our authors turn their talents to a problem closer to home. Though less dramatic, their choice is certainly pragmatic, and a worthy subject for their analysis.

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I. FORMULATION OF THE PROBLEM

A. The System

1. History of the Naval Postgraduate School Sailing Program

Sailing at the Naval Postgraduate School began in 1969 on an informal basis. Subsequently, an organized program under the auspices of the Recreation Department was established in 1970 by N.P.S. INST. 1710.11. From this beginning the activity and interest in sailing has grown until today there are over two-hundred people in the program.

Although the sailing program is financed and directed by the Recreation Department, it is, for all practical purposes, managed and operated by the officers of the Naval Postgraduate School Sailing Association (NPSSA), which was established by the 1970 instruction. The NPSSA Commodore has been designated as technical advisor on sailing matters, and renders such advice to the Recreation Director.

2. Objectives of the NPSSA

The NPSSA is a special-interest group organized and governed by a constitution approved by the Superintendent of the Naval Postgraduate School. The sailing program includes sailing instruction, recreational sailing and competitive sailing.

The objectives of the association are as follows:

a. Practice and learn the art of sailing.

b. Promote good fellowship and sportsmanship.

c. Learn and promote the rules and etiquette of yacht racing.

d. Promote competition (racing) between members of the Association and with other yacht clubs and sailing associations.

e. Procure, maintain and operate sailing craft for the use and recreation of members and their guests.

3. Yacht Inventory and Qualifications Procedure.

The current NPS yacht inventory consists of four 30-foot Shields sloops (one presently permanently chartered to Monterey Peninsula College), one 22-foot Santanna 22 sloop, and one 22-foot Columbia 22 sloop. The three Shields sloops available for NPS use are racing yachts, but are used a great deal for instructional and recreational sailing. The Santanna and the

Columbia are used almost exclusively for training and recreational sailing. Thus, the inventory consists of two basic categories: Shields (S) and Cruising craft (Cr). Due to some basic differences in the handling characteristics of these two classes, different levels of qualification are required of those entitled to "skipper" and check out each type of boat. The Shields can be checked out by skippers holding a class C (race) or B (Shields rated) qualification. The Cruising class can be checked out by both of the two above ratings and by B (Cruising) rated skippers.

4. Reservation Procedure and Skipper Population Statistics

Yachts are reserved on a first-come, first-served sign-up procedure. A weekly sign-up sheet is posted in the vicinity of the Recreation Office. Boats may not be reserved more than one week in advance, nor for more than one of the four sailing periods per day by the same skipper. Daily sailing periods are as follows: 0900 - 1100, 1100 - 1400, 1400 - 1700, and 1700 - sunset. Certain special racing events and training activities take precedence over recreational sailing.

Once a boat is reserved, the skipper and crew must sign it out before sailing and sign in after securing it. The trip is paid for with "chits" that the skipper attaches to his sign-out sheet.

The current population of qualified skippers, as determined from the records of the NPSSA, is 91 for Shields and 106 for Cruising boats. These figures were obtained from a count of the names that appear on the association roster. Unfortunately, the fact that an individual's name is on the roster does not guarantee that he or she is an active member in the sense that he or she sometimes requests and uses a boat. Since each person on the roster is at least a potential customer of the system and because it would be extremely difficult and time consuming to attempt to identify the active members, total skipper population figures will be used throughout the study.

B. Objectives of This Study

1. The primary purpose of this study is to gather information in order to answer the following pertinent questions concerning the system:

a. What type of boat (Shields or Cruiser) should be purchased next and what is the appropriate sequence of purchases thereafter?

b. How would the answer to the above change with system parameter changes?

2. The additional purpose of this study is to provide a means for the study team members to gain experience in conducting a thorough analysis of a system.

C. Measures of Effectiveness

1. This is potentially one of the most important areas of this study, for the measures of effectiveness that are selected will, in turn, determine the model to be used and ultimately the answer to the aforementioned questions. This arises from the fact that the output of any model will be interpreted in terms of the measure of effectiveness selected. Thus, it becomes extremely important to define what a measure of effectiveness is.

For this study, we shall consider a measure of effectiveness to be "a quantifiable measure of the extent to which system objectives are attained." It is in this light, then, that the objectives of the system must be analyzed to determine the measures of effectiveness (MOE) which are appropriate. The problem then becomes one of how to model the system to obtain values for the MOE that are selected and thus answer the questions posed.

2. An analysis of the specified and implicit objectives of the NPSSA led this study team to adopt the following MOE:

a. The expected percentage of boat periods available that will be utilized for Shields and Cruisers.

b. The expected percentage of boat periods available that the maximum number of boats available will be utilized.

c. The expected number of times (during one week) that a NPSSA member desires a boat of a particular type and that particular type is not available.

3. a. The values obtained for MOE 2a. above will be used in determining the answer to the question of the optimal procurement policy. The rationale is that the higher the expected utilization of a type of boat, the more it is to be preferred as the next purchase.

b. The value obtained for MOE 2b. above will also be used in determining the optimal procurement policy. The rationale is that the higher the expected maximum usage percentage, the more likely it is that this type of boat is preferred by the members and thus should be purchased first.

c. The value of MOE 2c. above will also be used in determining the optimal purchasing policy. The rationale is that the higher the expected number of times that a particular type of boat is not available to meet a demand, the more desirable that type is for the first purchase.

II. CONSTRUCTING THE MODEL

A. Counting Process Approach

A knowledge of the system and consideration of the MOE selected led this study team to first consider modeling the system as some form of a counting process. It was recognized that this approach might provide values for the first two MOE discussed and might not provide a value for the last MOE. Consequently, it was decided that another model of the GI/D/R form (where GI = General Input; D = Deterministic Service Times; and R = number of independent servers) might provide values for the third MOE selected.

In the case of the counting process approach, it was determined that it might be necessary to model each type of boat as a different process. Intuitively, it seemed that requests or demands of each type of boat would differ. This was later substantiated by a thorough examination of the data.

B. GI/D/R Process Approach

Although the results which appear for this section may be brief, this briefness is inversely proportional to the effort necessary to produce these results. In particular, the system was modeled as a M/D/R block system for Cruisers and Shields. (Where M = Exponential Interarrival Times; D = Deterministic Service Times; and R = number of independent servers. "Block" means that when the system is full, the arriving customer does not wait.) The results of this particular section can be derived from the examination of the classic 1918 paper of Erlang. The amount of study and effort of the team to come to this conclusion, interpret excerpts from the paper and to derive the results was monumental.

C. The Data

1. Collection Procedures

Initially it was necessary to decide whether to model the sign-up procedure or to model the actual usage of boats. In other words, the question was whether to extract data from the process of signing up or to extract the

data from usage reports. Since a person might sign up and then not actually use the boat, it was decided to look only at actual usage reports. These reports are known to be accurate due to the fact that "trip chits" described in NPS INST. 1710 must be attached, thereby verifying actual use of the boats.

In support of the third MOE discussed, it was deemed necessary to collect data concerning the times when someone desired a boat that was not available. Consequently, a special sheet was designed and posted next to the sign-up sheet in an effort to obtain this "balking" data. The results of this attempt were negative in the respect that no "balks" were indicated during a period of 2 months.

The choice of looking at actual usage data is not equivalent to observing the process at random points in time. Specifically, use of the actual usuage data provided observations only for those times which were the beginning of service or boat availability times.

2. Data Analysis

In attempting to get an intuitive feeling for the counting process, scatter plots of the arrivals of the Shields and Cruisers were constructed. The first plot constructed reflected arrivals of both types of boats and then a plot for each individual type of boat was constructed. Each of these plots generated information which was extremely valuable in the determination of the form of the arrival process.

From the scatter plots of each boat, the interarrival times were extracted. The results of this extraction provided the first lesson (insignificant or naive as it might seem) for this study team. The plot of the interarrival times for each process was unbelievably exponential. Initially, the reaction of the study team was great enthusiasm, but closer investigation revealed the following fault. Although the data would pass the Chi Square and K - S test for the hypothesis of an exponential distribution, it was obvious that many of the longer interarrival times occurred at the beginning of the week and many of the shorter interarrival times occurred toward the end of the week. In other words, the observations of the interarrival times appeared to lack time independence when considering the entire week. The hypothesis of time independence was tested using the "runs test" and the result was a miserable failure. Poof! There went our beautiful Poisson process.

With guarded enthusiasm, we began to consider the possibility of a nonhomogeneous process for each type of boat. Thus, we began to look at the scatter plots for segments of time wherein the arrival process might have the necessary qualities of a Poisson process. After conducting many unsuccessful tests of different time segments, we finally found 3 time segments for the Shields process and 2 segments for the Cruiser process. In each of these segments the Maximum Likelihood Estimator for λ was computed and a test of the hypothesis of an exponential distribution was successful. Additionally, the results of the runs test indicated time independence of the observations of the interarrival times within a particular segment. Finally, the coefficient of variation for each time segment was computed and it compared favorably to the desired value of 1.

Returning to the scatter plots for both boats, it was obvious that for each arrival from which interarrival times had been extracted there was the possibility of the arrival consisting of 1, 2, or 3 boat demands for Shields and 1 or 2 boat demands for Cruisers. In other words, not only was the process for each boat type nonhomogeneous, it was also compound. Letting X be defined as the random variable representing the number of boats demanded at the occurrence of an arrival, we began to consider the following questions:

a. What is the distribution of X for each type boat?

b. Is the distribution of X the same throughout the entire week - are the observed values of X independent of the time period?

c. If the answer to b. is negative, then what is the distribution of X_i where X_i is defined as the random variable X during time segment i.

d. Are the observed values of X_i time independent within the particular segment i?

Generally, if one considers a compound process to be such that each arrival is classified upon arrival, we were trying to establish the independence of this classification procedure from the arrival process. In our case, the independence of X was not present. Intuitively, this seemed correct, for it would appear that the form of boat demands would be much different on a weekend than during the beginning of the week.

As previously outlined, we next investigated the distribution of the number of demands within each time segment that had a homogeneous arrival process. In each case the distribution of the X_i was hypothesized and tested against the observed values using the Chi Square test. Then the time independence of data within a particular segment was tested using the runs test. In each segment, the distribution of X_i was found to be independent of the time of the arrival. Our conclusion was that the appropriate counting process model was of the form:

SHIELDS

$$Y(t) = Y_1(t) + Y_2(t) + Y_3(t)$$

$$= \sum_{i=1}^{N_1(t)} X_{i1} + \sum_{i=1}^{N_2(t)} X_{i2} + \sum_{i=1}^{N_3(t)} X_{i3}$$

where $N_i(t) \sim P(\lambda_i t)$

CRUISERS

$$Y(t) = Y_1(t) + Y_2(t)$$

$$= \sum_{i=1}^{N_1(t)} X_{i1} + \sum_{i=1}^{N_2(t)} X_{i2}$$

where $N_i(t) \sim P(\lambda_i t)$

Implicit in this model (referred to as the utilization model) is the assumption that the process for each time segment is independent of the process of another time segment.

By transforming the X_i's of the utilization model into M_i's, an indicator function of max usage, a model (referred to as the max usage model) was developed. All tests conducted for the utilization model are applicable to the max usage model. It is important to note that the form of this model is also nonhomogeneous and since M_i = 1 or 0, the process is Poisson.

Finally, the results of the analysis of the data indicated the use of the following specific form of a GI/D/R model:

SHIELDS M/D/3

where interarrival times $\sim Exp(\lambda_i)$ for each segment i

and service time = constant = 1 unit

where interarrival times $\sim Exp(\lambda_i)$ for each segment i
and service time = constant = 1 unit.

III. DERIVING A SOLUTION

A. General

1. Utilization Model

After a thorough analysis of the data to construct the model, the derivation of a solution was relatively easy. The technique of Laplace transformation was relied upon to allow the derivation of the generating function of the number of boat periods utilized, then the expected number of boat periods utilized was computed. This value was next used to determine the value of the MOE associated with percentage of utilization, then a comparison was made between the value of the MOE for each type of boat to determine the type of boat that should be purchased first. Under the assumption that no other changes in the system occur when another boat is purchased, it was possible to determine that the desired procurement sequence was Cruiser, Shields, Shields, Cruiser. It is important to observe that this sequence is based upon the MOE of percentage utilization only and does not consider the value of the other MOE.

In determining an answer to the second question of how the system changes with changes in the system parameters, a graphical technique was applied. For each type of boat a plot or graph of EY(t) as a function λ_i was constructed. Use of these graphs allows the prediction of values of EY(t) (and thus the MOE) for all values of λ_i. Obviously, this prediction assumes all other parameters remaining constant while only one parameter is varied.

2. Max Usage Model

The value of the MOE of percentage of max utilization was derived in a manner very similar to that used for the utilization model. Comparison of the value of this MOE for each boat provided an answer to the question of which type of boat to purchase first. However, prediction of an optimal sequence was beyond the capabilities of this model. This is due to the inability to change the M_i distribution when another boat of either type is purchased. In other words, it was not possible to predict how often an additional boat would be used.

Again, a graphical representation of how EY(t) changes with λ_i provides insights as to how the value of the MOE would change as the system

parameter λ_i is changed. As before, this prediction assumes all other factors remaining constant.

3. M/D/R Model

Evaluation of the MOE suited to this model allows a comparison between Shields and Cruiser nonavailability. This comparison provides an answer to the question of which type of boat should be purchased first. Additionally, making several iterations, with the number of boats that are in the system increasing by one with each iteration, allows the determination of the optimal procurement sequence. In this specific case, the expected number of blocks (nonavailabilities) was so low that the determination of the sequence was terminated after one iteration.

The question of how the value of the MOE changes as system parameters change could best be attacked through use of a computer to evaluate P_R for many values of λ_i. Because of the time necessary to accomplish such a task, this was not done during this study. An attempt to trace the change by using ordinary calculus techniques proved to be intractable.

B. Results

1. Procurement

Model	First Purchase	Procurement Sequence
Utilization	Cruiser	Cruiser, Shields, Shields, Cruiser
Max Usage	Cruiser	N/A
M/D/R	Cruiser	Cruiser, Shields

2. Changes in Parameters

Model	Region for which first purchase choice changes
Utilization	$\lambda_1 \leq .305$, $\lambda_2 \leq .329$, $31.5 \geq 52\lambda_1 + 36\lambda_2$
Max Usage	$\lambda_1 \leq .269$, $\lambda_2 \leq .217$, $.98 \geq 2\lambda_1 + \lambda_2$
M/D/R	Not computed

3. Summary

In terms of all MOE and all models, the first purchase should be a Cruiser.

IV. VALIDATION

A. Calculation Verification

All calculations were done at least twice; the second time being a check conducted with an electronic calculator.

B. Comparison of Model to Data

Extensive calculations were conducted with both the model and the data in order to prepare a comparison of the system values as the model dictates and the system values as the data prescribes. Where appropriate, the following system values were compared: EY(t), VarY(t), EX_i or EM_i, $VarX_i$ or $VarM_i$, $EN_i(t)$, $VarN_i(t)$ and the coefficient of variation. For each submodel of a particular time segment, these values compared quite favorably. In those cases where noticeable differences existed, the values were within the range of one standard deviation of the base value.

C. Other Validation

In addition to the formal measures previously mentioned, a careful examination of the model was conducted to determine if there were any predicted results that defied the intuition of the team members concerning the form of the actual process. No such faults were observed; in fact, the confidence we placed in the models was increased after making the comparison. For example (trivial), the model predicts higher utilization on the weekends than during the first part of the week. There are many other such intuitive checks that were conducted and satisfied.

V. SENSITIVITY ANALYSIS

A. General

The intent of the sensitivity analysis that was conducted during this study was to examine what change in the parameters of the model would be sufficient to change the results. To do this, it was necessary to investigate the change in the values of the MOE and to determine at what point a different value of the MOE would dictate a change in the procurement policy.

B. Method

In the case of the utilization model and the max usage model, the approach was to determine the rate of change of EY(t) with respect to each λ_i while all other parameters were held constant. By determining this rate it was possible to know how much change in λ_i was necessary to change EY(t) sufficiently to alter the procurement policy. In each case the solution to this problem was left in a form that allows determination of a change in policy by mere inspection. Finally, the same problem was solved when considering a change in two λ_i's at the same time.

C. Other Considerations

Another aspect of the models which has not been previously discussed is the assumption of an infinite population. This assumption manifests itself in the nature of the arrival process. In particular, an infinite population guarantees that when several members are in the system, the non-presence of these members in the out-of-system population does not affect or change the arrival rate. In the case at hand the question becomes whether 3 members out of a total population of approximately 200 can influence the arrival rate. We believe not. Furthermore, even if there is an influence, we believe this influence to be one which certainly would not change the values of the MOE that were obtained. This observation results from examination of the required change in the arrival rate parameters that was derived during the previous part of sensitivity analysis.

Our study team did not investigate the sensitivity of the results of the models to changes in the other system parameter, EX_i or EM_i. The reason for this is two-fold -- first, it is our opinion that changes in the other parameter, λ_i, were more likely (possibly from population changes) and, second, the change of EY(t) with respect to EX_i would be difficult mathematically, for the compound process used in the utilization model. Had more time been available, a careful analysis of the effect of EX_i and EM_i would have been conducted.

Finally, effects of the following factors were ignored throughout this study:

1. Weather
2. Races
3. School Schedule (exams and vacation periods)
4. Maintenance of Boats.

VI. IMPLEMENTATION OF THE MODEL

A. General

The NPS Recreation Department Director and the Commodore of the NPSSA are both aware that this study is being conducted and are anticipating its results. Needless to say, these people are not only concerned with a procurement policy, but also with the cost implications of procurement. Such considerations were beyond the scope of this study; however, it is the intention

of our study group to forward a summary of the results and recommendation of our efforts, in layman's terms, to the Recreation Director. The usage data will be explained, as well as the resultant procurement policy.

B. Plan

Under ideal circumstances, the implementation plan would also have to sufficiently explain the effect of population changes on arrival rate and the distribution of the X_i's. Additionally, since the people who need to use this study are not trained in the techniques that were applied, indicators of changes in arrival rates, X_i's, and possible balking would have to be devised and explained. Given these, a method for relating them to changes in procurement policy would be the next step. Our work concerning prediction and sensitivity analysis of the model is somewhat amenable to these requirements. However, it is our opinion that close examination of future data at regular intervals would best be accomplished under the supervision of someone qualified in the techniques of the study. Thus, our study group views the implementation plan as a continual effort requiring close coordination between the user (the Recreation Department) and the analysts.